

**BEFORE THE
FEDERAL COMMUNICATIONS COMMISSION
WASHINGTON, DC 20554**

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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF SECRETARY

In the Matter of)
)
Amendment of Parts 2 and 15)
of the Commission's Rules to Permit)
Use of Radio Frequencies Above 40 GHz)
for New Radio Applications)

ET Docket No. 94-124
RM -8308

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To: The Commission

**COMMENTS OF
HUGHES AIRCRAFT COMPANY
Communications Products Business Unit**

Hughes Aircraft Company, Communications Products Business Unit ("HCP") respectfully submits these comments in response to the *Notice of Proposed Rule Making* (FCC 94-273, released November 8, 1994) ("*NPRM*") in the above referenced proceeding

Summary and Introduction

1. HCP is a part of Hughes Aircraft Company that specializes in the development of microwave and millimeter wave subsystems and related components for voice and data communications. Hughes Aircraft Company is a leader in the development and manufacture of sophisticated electronics equipment. Consistent with

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HCP's expertise, these Comments focus on the need for provisions in the millimeter wave region for frequency bands that will support high speed point-to-point links.¹

2. HCP agrees with the Commission on the important public benefits that can result from opening up the millimeter wave-band for use by the public. We commend the Commission for its forward looking stance. After examining the proposals in the *NPRM*, HCP would like to propose a few modifications that will help the Commission to achieve its objective of allowing the millimeter wave-band to contribute to the National Information Infrastructure (NII) by supporting high speed digital links that will help businesses, government and non-profit institutions connect their buildings together and to the NII. While the Commission does recognize that millimeter wave devices are best used for short-range applications, without the modifications that HCP advocates, the contribution of millimeter wave devices will be limited to very-short range links.

3. The changes HCP recommends are as follows:

- o Allow general unlicensed devices to have EIRPs up to 16 dBW when they are professionally installed and have adequate warning labels. This should provide the Commission with adequate assurance that its requirements on RF exposure are being adhered to.
- o Make the restrictions on the power of licensed transmitters forward looking toward the state-of-the-art by allowing EIRPs up to 50 dBW.
- o Make adequate provision for high speed data links that can support Asynchronous Transfer Mode (ATM) by allocating a licensed point-to-point band at 71.0-73.5 GHz. If this proves impossible, the alternatives are to allow professionally installed general unlicensed devices in the 59-64 GHz band to have 50 dBW EIRP or creating a separate licensed band at 61.5-64.0 GHz.
- o Impose reasonable requirements on the required suppression of out-of-band signals by imposing a level of 30 dBc [with a maximum upper limit of 0 dBW (EIRP) on spurious signals]. Only require measurements up

1 HCP notes that General Motors Corporation and GM Hughes Electronics are also filing Comments. Hughes Aircraft Company is a wholly owned subsidiary of GM Hughes Electronics. The GM Comments address the *NPRM*'s proposals for vehicular radars. While HCP fully supports the GM Comments, this document addresses HCP's views on the *NPRM*'s proposals for general unlicensed and licensed bands.

to 160 GHz because of the difficulties in calibrating test equipment and make clear that the limits imposed apply to values measured in the far field.

Need for Accessible Pt-Pt Links

4. A crucial component of the NII will be short and medium range high speed point-to-point data links. These links are vital to creating Wide Area Networks ("WANs") that allow high speed data interconnection between various locations of a corporation, government agency, university campus, or other non-profit institution such as hospitals. Ranging from going across the street, to across a campus quadrangle, to distances of a few kilometers, millimeter wave devices will play a crucial role in allowing economical high speed interconnection. The other key application is to connect these WANs to the long haul networks that comprise the backbone of the NII. As the use of graphical computer interfaces (such as the World Wide Web), multi-media information sources, and other wideband data applications grow, the need is for even higher speed point-to-point links to support data networks such as Asynchronous Transfer Mode ("ATM"). As the *NPRM* points out only at millimeter wave frequencies is there the RF bandwidth to support such high speed data links.

5. The growing expansion of mobile communications, especially the Commissions' recent action authorizing broadband Personal Communications Services (PCS) has also increased the need for high speed short and medium range data links. Point-to-point links operating at millimeter wave frequencies will play an increasingly significant role in these mobile networks to supply base station to base station and base station to Mobile Telephone Switching Office (MTSO) applications.

6. While there is a clear need for millimeter wave point-to-point links, a close review of the proposals in the *NPRM* reveals that there are significant limitations. The proposed licensing structure will essentially make the licensed bands unavailable to anyone other than the auction winners and the power limitations proposed for the

general unlicensed bands will make them unusable for communicating at any reasonable distance. However, HCP believes that with small modifications, these difficulties in the *NPRM* can easily be overcome.

Licensing Structure

7. HCP agrees with the Commission that there is a need for additional spectrum that can serve the purposes similar to the Local Multipoint Distribution Service (LMDS).² Thus, the basic regulatory framework proposed in the *NPRM* for licensed bands is appropriate, i.e. auctioning off wide bandwidths on a Major Trading Area basis. However, this has the significant disadvantage that it will make it essentially impractical for any entity other than the auction winner to use these bands for point-to-point channels. As discussed below HCP does not believe this is necessarily a problem if the Commission can make appropriate adjustments in the structure of the unlicensed bands. If these adjustments prove impossible, then it will be necessary to make adjustments in the proposed format for at least some of the Licensed bands. These modifications are discussed below.

Unlicensed Power

8. The fundamental problem with the unlicensed bands is that the proposed power level in the *NPRM* is simply too low to accomplish communications over any reasonable distance. The proposal is to only allow -6 dBW (1/4 of a watt) EIRP (Equivalent Isotropic Radiated Power). At millimeter waves this is nowhere near enough power to go reasonable distances.

9. According to the *NPRM* (at ¶¶38-40) the low power limit is the result of the Commission's need to be assured that exposure in excess of the applicable standard(s) on RF exposure do not occur. As discussed in detail below, HCP believes that "professional installation" and appropriate warning labels will provide the

² See, *Notice of Proposed Rule Making, Order, Tentative Decision and Order on Reconsideration*, CC Docket No. 92-297, 8 FCC Rcd 557 (1993).

Commission with sufficient assurance. This will allow, under appropriate conditions, sufficient power to meet most of the needs for short range links within the unlicensed bands.

General Unlicensed Bands

10. The key to using the general unlicensed bands for links that will reach an adequate distance is to allow transmit powers substantially higher than is proposed in the *NPRM*. The basis for the proposed power limit of -6 dBW EIRP is the calculation (using a far field relationship) that at 2 cm from the center of radiation, the power density will be 5 mW/cm². This is the limit for RF exposure in the current American national standard that the FCC uses for evaluating whether an Environmental Assessment is required at all frequencies under consideration in the *NPRM*.³ While this approach has the beneficial quality that it provides essentially ironclad assurance that no millimeter wave general unlicensed device will ever subject a person to exposure levels in excess of the levels requiring an Environmental Assessment, it is clearly excessive in most circumstances. Any higher power device installed in circumstances where people will not be "close" to the main beam of the device for a substantial part of a minute or more will not cause exposures in excess of the standard.⁴ Examples include communications links next to the window and pointing outward, antennas mounted on

3 As the *NPRM* discusses (at ¶¶37-40) the Commission rules [at §1.1307(b)] currently reference the use of American National Standard ANSI/IEEE C95.1-1982 "Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 300 kHz to 100 GHz." In its *Notice of Proposed Rule Making*, ET Docket No. 93-62, 8 FCC Rcd 2849 (1993) the Commission is considering whether this reference to the 1982 version should be changed to the updated version of this standard, ANSI/IEEE C95.1-1992 "Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz." In the 1992 version, the relevant exposure limit is doubled to 10 mW/cm². As the *NPRM* in this proceeding notes (at ¶39), there have been comments in Docket 93-62 which oppose this increase in the limit. We agree with the Commission's decision to defer the issue of which exposure level to use above 40 GHz to Docket 93-62.

4 As discussed below, under the HCP proposed power levels, "close" may be on the order of 10 inches.

the sides of buildings or from poles above the building. Most fixed licensed transmitters rely on these and other measures to insure that the RF exposure limit is not exceeded.

11. When dealing with the traditional "shrink-wrapped Part 15 toy," the *NPRM*'s proposal is probably the correct approach. Without it, the probability that someone will use a general unlicensed millimeter device in inappropriate circumstances is simply too high. However, many if not most of the general unlicensed millimeter devices will be custom installed in commercial, institutional, and industrial areas to perform important activities. This is particularly true of wide area network links using point-to-point millimeter devices. These links will be crucial to the organizations using them and will not be simply "bought off the shelf."

12. HCP believes that the key to prudently allowing some unlicensed devices to use higher powers is restricting these higher powers to professionally installed devices with appropriate warning labels. In an analogous situation, the FCC already grants more freedom when Part 15 devices are "professionally installed." Section 15.203 requires that antennas on intentional radiators (i.e. transmitters) must have a "unique" coupling unless it is "professionally installed."⁵ In this case, the Commission was concerned that the owner of a Part 15 intentional radiator would simply replace the antenna supplied by the manufacturer with a higher gain antenna resulting in a unit that no longer met the FCC rules. Without the unique coupler requirement, neither the FCC nor the manufacturer would have any control over what happened with traditional Part 15 devices bought by members of the general public. In cases of professionally installed devices, the FCC has not only the participation of the professional installer but the additional protection that the user of the device is concerned about the device's performance and will usually be more careful about using appropriate replacement

5 There is also an exception for intentional radiators that must be measured on-site, but that is not relevant to this discussion.

parts, etc.⁶ HCP proposes that devices with EIRPs in excess of -6 dBW must be professionally installed and that the installer is responsible for insuring that the installation is appropriate for the power level of the device so that people will not be within the critical distance of the device's antenna.⁷

13. In addition HCP believes that the Commission should require appropriate warning labels to be placed on the device to warn users about inappropriate situations. Since the device will be professionally installed in an appropriate location, the warning labels are merely providing supplemental protection, warning the users and passersby not to do unusual things in the immediate presence of the device. This is analogous to high voltage warning signs which are not the primary protection against electric shock. The signs do, however, provide a useful warning to passersby not to scale the fence or break into the equipment bay.

14. With the exception of the 59-64 GHz band (discussed below), HCP proposes that the maximum allowed EIRP for general unlicensed devices be +16 dBW.⁸ This should in most cases allow sufficient power to obtain communication ranges up to a few kilometers. With this power limit, the "stand-off" distance at which it is clear that any human exposure meets the 5 mW/cm^2 exposure criteria is only 10 inches.⁹ Thus, it will not be very difficult to install the device in a way that assures that people will not come within 10 inches of the front of the antenna. Further,

6 Note that the last sentence in §15.203 holds the installer "responsible for insuring that the proper antenna is employed."

7 Under §2.1033(b)(3) the Commission requires that applications for Certification (the proposed equipment authorization procedure for unlicensed devices) must include copies of the "installation and operating instructions." This will provide an additional mechanism by which the Commission can verify that the instructions prepared for the professional installer adequately address the issue of RF exposure (and whether the operating manual has the appropriate warnings for users).

8 If the Commission would prefer to state the limit as a power density measured at 3 meters it would be 35 microwatts per square centimeter

9 One caveat is that the standoff distances were computed using a far field relationship, $S = \text{EIRP}/4\pi R^2$. Since the calculated standoff distances are in the near field of most devices, actual near field measurements may vary slightly from the calculated value.

communication links will naturally be set up to avoid anything, including people, from blocking the path for distances far in excess of 10 inches. Combined with the professional installation and warning labels, this should provide more than sufficient assurance to the Commission that its RF exposure guidelines are being adhered to.

Licensed Bands

15. If the Commission adopts HCP's proposal to allow increases in power in the general unlicensed band, then most of the need for WAN links can be met within those bands. Under that condition, the practical unavailability of Licensed bands for point-to-point links other than for the needs of the auction winners will not be a serious issue. If the Commission concludes that it must have more assurance about exposure levels resulting from professionally installed unlicensed devices, then it needs to modify the *NPRM*'s operating assumption that all of the licensed bands will be devoted to wide area coverage by two licensees (§§22-28). In particular, it needs to allocate one or more of the lower frequency licensed bands for traditional point-to-point links, e.g. Point-to-Point Microwave Radio Service in Subpart I of Part 21.

16. Assuming professionally installed general unlicensed devices are allowed adequate power, with the possible exception of the 71.0-71.5 GHz licensed band, HCP's major observation is on the proposed power limit. While most point-to-point links in the licensed band will be owned by the licensee this will still be a substantial number. The only way to achieve the wide area, high capacity coverage envisioned for the Licensed Millimeter Wave Service (LMWS) in the *NPRM*, is to use a large number of distribution points to the subscribers. These distribution points have to be interconnected with point-to-point links, many of which are likely to use the same frequency band. Thus, it is still important that the technical rules for the Licensed bands readily support medium distance point-to-point links.

17. The *NPRM* (at ¶33) proposes licensed transmitters be limited to +16 dBW EIRP. Higher power transmitters will be considered on a "case-by-case basis subject to coordination with affected licensees." The +16 dBW EIRP limit is based on 10 mW (-20 dBW) transmitters which the *NPRM* describes as "likely to be typical of commercially-affordable microwave circuits in the near future" and an antenna gain of 36 dB, which again the *NPRM* describes as "typical of economical antennas and transmission systems in the near future."

18. HCP believes that this seriously understates the power levels that are likely to be used, at least for point-to-point links. Currently, commercially available millimeter wave sources (either Gunn Oscillator or Gallium Arsenide monolithic microwave integrated circuits (MMICs) amplifiers) are capable of generating a few hundreds of milliwatts in the frequency range of 40 GHz up to 75 GHz. The power capability will further improve in the very near future. Further, antenna gains as high as 50 dBi are readily available. Thus, EIRPs as high as +50 dBW will be easily achievable.¹⁰

19. Given the Commission's goal of "opening portions of the millimeter wave spectrum ...[to] stimulate new applications of radio technology for the American public, facilitate technology transfer from the military sector, and create opportunities for economic growth and jobs" (*NPRM* at ¶7), it would be unfortunate if the rules adopted from this proceeding were to severely limit these opportunities. Thus, HCP believes that the proposed power limits need to be substantially raised. HCP recognizes, and appreciates, the Commission's stated willingness to "consider higher power limits on a case-by-case basis" (*NPRM* at ¶33), but we believe that mandating

10 RF Exposure concerns are not a bar to higher powers in the Licensed bands. The Commission's rules already hold radio licensee responsible for reporting to the Commission any cases where RF exposure exceeds the applicable standards, exposing the licensees to serious sanctions for failure to comply.

case-by-case applications to the Commission for all transmitters over +16 dBW will simply overburden both the Commission and licensees with paperwork.

20. HCP recommends that, at least for point-to-point links, that the allowed EIRP limit be raised to +50 dBW.¹¹ A coordination requirement among licensees in any band will easily resolve any potential interference concerns. This should not be burdensome to licensees and need not involve the Commission's staff in the process. Point-to-point links with their highly directional antennas at both the transmitter and receiver have low interference potential, the atmospheric attenuation of millimeter waves reduces significantly the distances at which coordination needs to be done, and the large area involved in a Major Trading Area limits both the number of cases which will affect any other licensee and the total number of licensees involved in the coordination process.¹²

Provisions for High Speed Short and Medium Distance Links Needed

21. In the Introduction to the *NPRM* (§2), the Commission discusses its desire "to permit the development of short-range wireless radio systems with communications capacities approaching that now achievable only with coaxial and optical fiber cable." HCP agrees that this is a significant need, especially for links connecting locations of WANs. In order to be effective in meeting the needs of ATM networks, data speeds of at least 1 Gb/s are required. Unfortunately, if short range is to be more than very

11 Lower power limits on the sector antennas that may be used for the short range final link to the end customer may be appropriate. First, the wide-angle coverage may make coordination more difficult. Second, the significantly lower gain of wide-angle antennas makes the possibility of such high EIRPs unlikely.

12 The *NPRM* (at §32) asks about whether the licensed bands can effectively be shared with Government users. There may be some problems coordinating Government usage with the wide-angle end links of the LMWS and it is clear that any potential bidder will need adequate knowledge about Government usage before the auction. With respect to the point-to-point links discussed in these Comments, however, sharing with most Government users is unlikely to be a significant problem.

short, bands on the order of 2.5 GHz are needed (to provide for two-way links). There is no proposed licensed band with 2.5 GHz bandwidth.¹³ HCP has three alternatives to propose to meet this requirement.

22. The proposed 59-64 GHz general unlicensed band has adequate bandwidth. Unfortunately this band is also inside an Oxygen molecule absorption band. To achieve any sort of distance reliability, powers substantially higher than the +16 dBW EIRP that HCP recommended is needed. To achieve ranges more than a kilometer or so, powers up to +50 dBW are required.¹⁴ This would clearly be the simplest way to allow for short and medium length ATM interconnection links, although it might be appropriate to limit this higher power to the upper portion of this band (61.5-64.0 GHz). However, HCP recognizes that the Commission may be reluctant to allow transmitter EIRPs of +50 dBW (100 kW) without having the positive assurances of a signed statement from a licensee that the RF exposure guidelines are being met.¹⁵

23. HCP's second alternative is to propose that the 59-64 GHz band be subdivided into a general unlicensed band from 59.0-61.5 GHz and a licensed point-to-point band from 61.5-64.0 GHz. Within the licensed bands, links with +50 dBW EIRP can readily be accommodated under the Commission's normal licensing provisions. This alternative has the disadvantage that it prevents very wideband (over 2.5 GHz) general unlicensed devices.

24. HCP's third alternative is to provide a new 2.5 GHz wide licensed band for point-to-point links. One way of achieving that would be to expand the proposed

13 While the lowest proposed Licensed band, 40.5-42.5 GHz, has a 2 GHz bandwidth, HCP assumes that this band is the most likely to be used for wide area LMDS-like services. None of the higher proposed licensed bands have anywhere near this much bandwidth.

14 Even with that high a power, it will probably be necessary to adaptively lower the data rate in the middle of heavy rain cells.

15 The stand-off distance is approximately 41 feet in the main beam for a 100 kW EIRP and an exposure standard of 5 mW/cm². Antennas set on the top of multi-story buildings can easily comply with the standard.

71.0-71.5 GHz licensed band to 71.0-73.50 GHz. While this would eliminate the proposed 71.5-72.0 GHz general unlicensed band this should not be significant since general unlicensed devices would still have the entire 59.0-64.0 GHz band and the 84.0-84.5 GHz band available to them. This may be the best alternative, provided that the FCC can obtain NTIA concurrence for this proposal.¹⁶

Technical Issues

Out-of-Band Suppression Requirements

25. The *NPRM* proposes (at ¶41) that -6 dBW EIRP transmissions from general unlicensed devices have all out-of-band emission EIRP's below -56 dBW (2.5 uW), i.e. 50 dB down. This is extraordinary performance to require in millimeter devices. Not only is it very difficult to achieve, but it is equally hard to measure in the real world. HCP suggests that a requirement for 30 dB down is far more realistic for general unlicensed devices, even at the higher EIRP of +16 dBW that HCP is proposing.

26. With respect to licensed devices the *NPRM* (at ¶34) proposes that out-of-band emissions be at the same absolute level as from far lower power unlicensed devices. This would result in a totally unreasonable requirement for 72 dB of suppression with the power limits proposed in the *NPRM*, +16 dBW EIRP. As was discussed above HCP feels that the licensed service should be allowed even higher powers. Without a change, this proposal would require higher (and more unreasonable) suppression. HCP

16 Given the ease of coordinating point-to-point millimeter wave links, there is no reason why this band cannot be shared between Government and non-Government links.

proposes that licensed transmitters attenuate all out-of-band emissions by 30 dB, however no EIRP of an out-of-band emission can exceed 0 dBW.¹⁷

Measurements

27. Measurements up to 200 GHz are proposed for millimeter wave devices in the *NPRM* (at ¶¶36, 45). HCP believes that unlicensed devices at 153 GHz (or vehicular radars at 154 GHz under the AAMA and GM proposals) will be the highest frequency actually utilized for a significant period of time. Further there are significant technical problems with performing measurements above about 160 GHz. First, it will be quite some time before measurement and instrumentation calibration standards will be available at these high frequencies. Currently, the maximum frequency covered by the NIST standard is about 100 GHz. The current alternative is using either dry or wet calorimeters. According to the NIST Microwave Metrology Department, and several leading millimeter wave companies, the accuracy of this approach is limited to about $\pm 20\%$. Given these significant measurement problems, HCP recommends that the upper frequency bound on measurements be limited to 160 GHz.

28. For the unlicensed service, the *NPRM* specifies the power and spurious limits in a power density measured at a distance of 3 meters from the device.¹⁸ The *NPRM* clearly uses far field relationships in calculating the equivalent EIRP.¹⁹ However, with many of these devices, 3 meters will be in the near field. Thus, it is possible that measurements at 3 meters will overestimate the actual EIRP. With millimeter wave devices, the clearly important value for spectrum management is the

17 In ¶34, the *NPRM* asks whether the frequency stability requirements traditionally imposed on Part 15 devices, -20° to $+50^{\circ}$ C is appropriate. HCP agrees they are sufficient. No separate frequency stability requirements, etc. are required, provided the signal remains within its assigned frequency over the -20° to $+50^{\circ}$ C range. The *NPRM* also asks about the need for susceptibility standards for licensed equipment. HCP believes that there will be sufficient market pressure to insure adequate susceptibility performance and there is no need for explicit FCC action.

18 See proposed section 15.253 in Appendix B of the *NPRM*.

19 See footnote 35 to ¶38 of *NPRM* where the limit of 200 nW/cm^2 @ 3m is equated to an EIRP of 0.25 W.

actual EIRP. The Commission should make it clear that applicants are free to take measurements in the far field region and extrapolate back to a 3 meter value by using the $1/R^2$ power relationship, and that these far field results supersede measurements actually taken at 3 meters when this distance is within the near field.²⁰

CONCLUSION

29. For the reasons discussed above, HCP urges the Commission to promptly adopt the *NPRM* with the modifications discussed above.

Respectfully submitted,

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January 30, 1995

²⁰ Note that this is completely consistent with the $1/R$ relationship specified in §15.31(f)(1) since all of the existing power limits in Part 15 are specified in field strength (V/m). Both $1/R$ in field strength and $1/R^2$ in power provide the 20 dB/decade factor specified in the rules for over 30 MHz.

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